5.2. Overview Supply model

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Overview

- Reminder: agricultural supply analysis
- Structure of the supply module
  - Objective function
  - Constraints
  - Decision variables & Reporting
  - Data
- Technical implementation

Background: specification procedures different between PM and SE

Mathematical Programming (PM)

Approach: Input allocation to various production activities using an explicit optimisation often characterized as normative

Pros: PM can be used to explicitly model technological/policy constraints

Cons:

- no statistical estimation, data demanding
- can yield in corner solutions and calibration is difficult -> Howitt (1995a) presented 'Positive Mathematical Programming', PMP now a widely used approach also in CAPRI
- see Davit's session on PMP calibration

System of equations (SE)

Approach: System of equations, closed-form solutions, with behavioural function

Pros: SE can use econometric techniques, parametric specification based on observed supply and demand

Cons:

- Particular as constraints (water, land, ..) cannot be easily incorporated and the choice of functional form is restricted
- This limit the model's complexity -> and limits for differentiated analysis

Structure of the capri supply model

- Each Nuts2 region in the EU (including Norway, Balkan, …) is presented by a mathematical programming model and maximizes profit
- A regional MP model operate independent
- To obtain the supply for the EU, all 270 Nuts2 optimization results need to sum up (by product)
- All Nuts2 models are calibrated to the observed or projected values, as in 2030

Didactic structure of the supply module

- Linear Programming model

3. Decision Variable	Wheat	Barley	Potato	Maize			
GVA	1200	800	1300	1300		1. Object function	
	4. Data or Parameter					2. Constraints	
	1	1	1		<	10	Quota
	20	24	50	13	<	2000	Labour
	1	1	1	1	<	100	Land

Supply Model maximize profits subject to constraints exogenous prices

Subsidies

Gross value added

Revenues – variable costs

Objective function

Max profits =

gross value added

+ subsidies

- PMP

PMP

- Additional cost or revenue
- for activities
- for land classes
- for feeding
- Estimated from time series for crops

Land Balance

Crop nutrients

Nutrient supply = nutrient removal

- Nitrogen (N)
- Phosphorous (P)
- Potassium (K)

Constraints

Equations constraining the model

- Technical (feeding, nutrients,...)
- Political and environmental (set-aside, greening, ...)

Political

- Greening requirements
  Eco. focus area <
  + Grassland share
  + Crop diversity
  + Winter greening
  + Set-aside

Feeding

- Using regional fodder
- Using purchased feed
- Cover animal requirements of
  - Energy
  - Protein
  - Various fibres
  - Dry matter

Data

Parameters of the supply module

- Prices for all products
- Yields, young animal replacement
- Feed requirements
- Nutrient requirements per crop
- Nutrient content of fodder and crops

Most data are organized in the parameter Data

More next presentation

Decision variable

Technical implementation: CAPMOD Reminder

Objective function

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- PMP

Gross value added

Revenues – variable costs

Revenues

Primary crop products such as cereals, oil seeds, …

- Young animals
- Meat: Slaughter takes place on farm
- Raw milk: the dairy is in the market model

Note: Manure and roughage (gras, silage)

are not traded but handled on farm via constraints

Variable costs

- Purchased inputs:
  - Fertilizers
  - Plant protection
  - Seed
  - Certain maintenance
- Young animals
- Feed concentrates incl. cereals

Subsidies

Coupled payments

- First pillar: Voluntary coupled support (VCS) Crop specific (Cotton), Complementary National Direct Payments (CNDP)
- Second pillar: Agri-Env Payments, N2k, LFA

Nominal amount per unit

List of eligible activities
All activities eligible => decoupled payment
Top-ups for selected production techniques

Ceilings
- Value ceilings (envelopes)
- Quantitative (entitlements)

IF ceiling overshot
THEN cut payment to fit ceiling

Decoupled farm payments

- **Coupled but everything eligible (BPS)**
- **Greening requirements**
  - Crop diversity
  - Grassland share
  - Winter green
  - Eco. focus areas
- 30% of payment can be reduced

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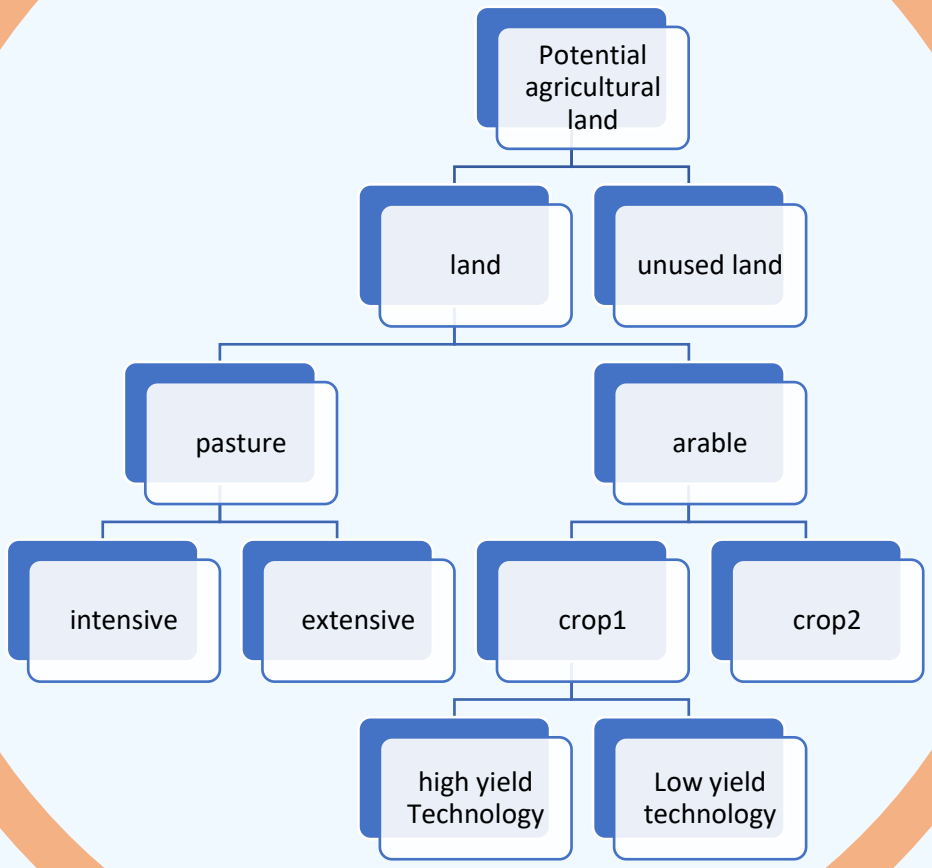
Land Balance



Decision variable

Gams\supply\Supply_model.gms

```
Variables/
v_obje                          "Objective value"
v_actLevl(RALL,COLS,*)          "Level of Production activities in 1000 ha or 1000 heads"
v_youngAnimUse(RALL,OM)         "Intra-aectoral use of young animals in 1000 heads"
v_feedQuantReg(RALL,*)                  "Regional feed use in 1000 t per year and herd"
v_feedInpCoeff(RALL,MAACT,A,*)          "Feeding per head and day in kg fresh weight"
v_netPutQuant(RALL,*)                   "Selling and buying activities in 1000 t, neg means
buying"
v_lossQuant(RALL,ROWS)          "Losses of straw and organic fertiliser in 1000 t"
v_fertDist(RALL,*,FNUT,*)       "Distribution of organic and mineral N to groups of crops, in 1000 t"
v_ManureNPK(RALL,*)             "Total N,P,K at tail net of gaseous v_lossQuant in 1000 t"
…
/;
```

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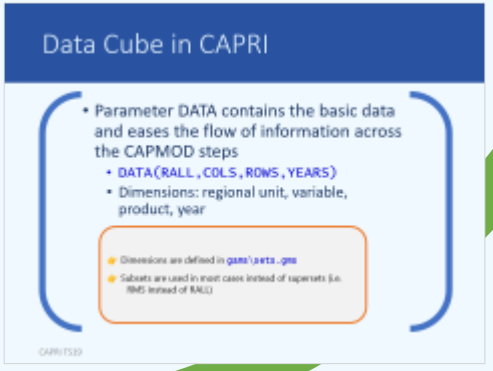


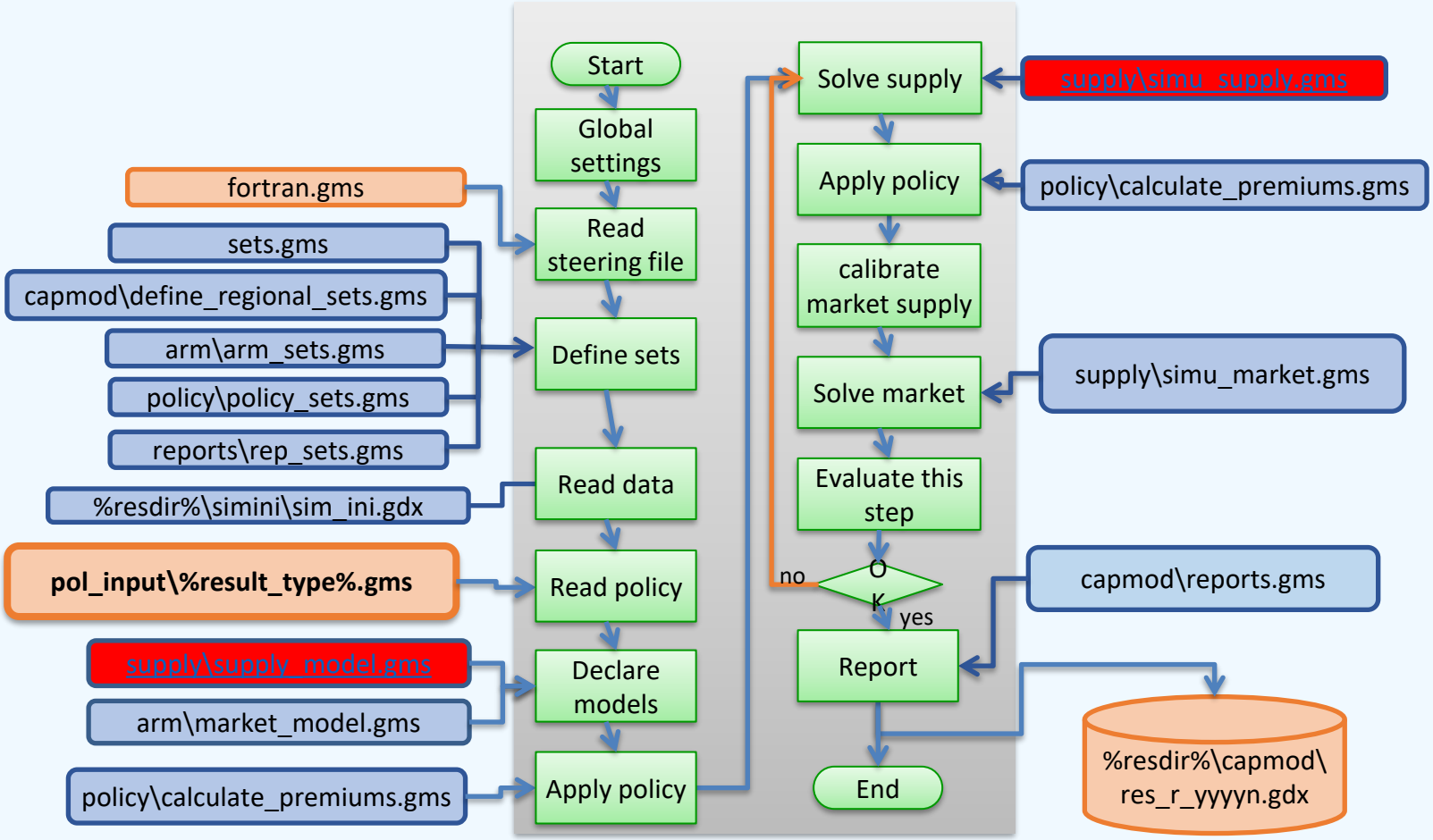
Data Cube in CAPRI

- Parameter DATA contains the basic data and eases the flow of information across the CAPMOD steps
  - `DATA(RALL,COLS,ROWS,YEARS)`
  - Dimensions: regional unit, variable, product, year

☞ Dimensions are defined in `gams\sets.gms`

☞ Subsets are used in most cases instead of supersets (i.e. RMS instead of RALL)

Technical implementation: CAPMOD Reminder



Supply_model.gms

```
@purpose  : Definition and declaration of variables,
VARIABLES
       v_obje                       "Objective value"
       v_actLevl(RALL,COLS,*)       "Level of Production activities in 1000 ha or 1000 heads"
       v_netPutQuant(RALL,*)        "Selling and buying activities in 1000 t, neg means buying"
…

EQUATIONS
        OBJEQF_                     "Objective: Income of agriculture + PQP-terms + PQP-feed-terms"
        SUPBAL_                     "Supply balances for final outputs"
        NUTNED_                     "Nutrient need of crops must be covered by fertilizing"
        permGrasGreening_(RALL)     "Greening requirement to keep permanent grass lands"
        ecoSetAside_(RALL)          "Greening ecological set-aside"
        winterCover_(RALL)          "Winter cover requirement"
        LandBal_                    "Land balances - either fixed endowments or market clearing"
        REQSE_                      "Requirements of animals written as equality"
```

Definition of decision variables

Definition of equations for the objective function

Definition of equations for defining constraints

```
LandBal_(RUNR,landTypesBal)  ..
*   --- sum of crops using that land type = total area of that type
       SUM( (landTypes_to_pact(landTypesBal,MPACT),A) v_actLevl(RUNR,MPACT,A)) =L=
          + v_actLevl(RUNR,landTypesBal,"T");
```

constraint: land balance nest 2
crop1 + crop2 = arable
intensive and extensive grassland = grassland

```
MODEL m_capMod/
                OBJEQF_,
                SUPBAL_,
                REQSE_,
                NUTNED_,
                SETAN_
                winterCover_
                ecoSetAside_
                cropDivGreening_

…
                /;
*
mm_capMod.RESLIM    = 1*60 * 100/6;
m_capMod.ITERLIM    = 10000;
m_capMod.SOLPRINT   = 2;
m_capMod.SOLVELINK = 2;

…

MODEL m_capModQ/ m_capMod,
                QUADRF_
                LandBal_
…
```

MP model definition LP

model NLP with PMP terms

simu_supply.gms

```
$include supply\def_start_value_and_data.gms
$setglobal CAPMOD m_capModQ
*
 %capMod%.iterlim    = 10000;
 %capMod%.tolinfeas  = 1.E-5;
 INFES(RU,"SUPPLY")  = NO;
 %capMod%.holdfixed  = 1;
 %capMod%.solprint   = 2;
 %capMod%.sysout     = 2;
 %capMod%.limrow     = 0;
 %capMod%.limcol     = 0;

              LOOP(RU_SMALL(RU),

                   if (SUM(RU_MS(RU,MSACT),1) eq 0,
                      option kill=MSACT;
                      MSACT(MS) $ RU_MS(RU,MS) = YES;
                   );
*
*                   --- include current regional unit in dynamic set on which
*                       equations are defined in supply.gms
*
                   option kill=RUNR;
                   RUNR(RU) = YES;

                   SOLVE %capMod% USING NLP MAXIMIZING v_obje;
*
*                  --- if the region was not feasible or not optimally solved
*                      resolve, and eventually widen bounds (should normally
*                      not happen)
*
$                  batinclude 'supply\widen_bounds.gms' RU

              );
```

Set Start values for the decision variable like v_actLevl

Define the NLP model name as global and related default settings to the model

Loop over all Nuts2 region of the selected MS

Solve the model

Include a file which checks if the model run

Thank you! Questions?

slido

Scenario snippets files are stored in the following folder

ⓘ Start presenting to display the poll results on this slide.

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Scenario files which can be selected from the task (run scenario with and without market model) are stored in the folder

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Additional result type identifier (debug option) allows to add to the gdx result file name located in \output\results\capmod

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The equation of the supply model are defined in the file:

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What are the two main modules (models) of CAPRI?

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What is the regional disaggregation in the supply module?

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What is the coverage of the supply models

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The regional MP model ..

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What are the advantages of mathematical programming models?

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What are the most important constraints in the supply model?

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The objective function contains ..

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What are the consequences of a tax for production of mineral fertilizer in the EU?

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